



US009038037B1

(12) **United States Patent**
Biggerstaff

(10) **Patent No.:** US 9,038,037 B1
(45) **Date of Patent:** May 19, 2015

(54) **AUTOMATICALLY SOLVING SIMULTANEOUS TYPE EQUATIONS FOR TYPE DIFFERENCE TRANSFORMATIONS THAT REDESIGN CODE**

(71) Applicant: **Ted James Biggerstaff**, Austin, TX (US)

(72) Inventor: **Ted James Biggerstaff**, Austin, TX (US)

(73) Assignee: **Ted J. Biggerstaff**, Austin, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/337,487**

(22) Filed: **Jul. 22, 2014**

(51) **Int. Cl.**
G06F 9/45 (2006.01)

(52) **U.S. Cl.**
CPC **G06F 8/437** (2013.01)

(58) **Field of Classification Search**
USPC 717/114–116, 141–143, 101, 108, 140
IPC G06F 17/30731, 17/30864, 8/20, 8/21,
G06F 8/36

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,923,879 A *	7/1999	Sasmazel et al.	717/143
6,754,887 B1 *	6/2004	Gil et al.	717/116
7,096,455 B2 *	8/2006	Santiago	717/114
7,165,237 B2 *	1/2007	Thiruvillamalai	717/108
7,254,808 B2 *	8/2007	Trappen et al.	717/143
7,496,892 B2 *	2/2009	Nuss	717/114
7,571,425 B2 *	8/2009	Lessly	717/108
7,631,291 B2 *	12/2009	Shukla et al.	717/107
7,680,935 B2 *	3/2010	Szyperski et al.	709/226
7,681,186 B2 *	3/2010	Chang et al.	717/143

7,761,858 B2 *	7/2010	Chang et al.	717/140
7,810,080 B2 *	10/2010	Plum et al.	717/140
7,836,428 B2 *	11/2010	Mitchell et al.	717/117
8,042,090 B2 *	10/2011	Janiesch et al.	717/102
8,296,730 B2 *	10/2012	Whitechapel et al.	717/116
8,843,877 B2 *	9/2014	Dutta et al.	717/101
8,949,784 B2 *	2/2015	Langworthy et al.	717/117

OTHER PUBLICATIONS

Mishra et al, "Declaration-free Type Checking", ACM, pp. 7-20, 1984.*

Najjar et al "The role of constructor in the context of refactoring object oriented systems" IEEE, Proceedings of the Seventh European Conference on Software Maintenance and Reengineering (CSMR'03) pp. 1-9, 2003.*

Bessonov et al, "Integrability Conditions for Parameterized Linear Difference Equations", ACM, pp. 45-52, 2013.*

(Continued)

Primary Examiner — Anil Khatri

(57) **ABSTRACT**

A method and a system for first, expressing relationships between design contexts as a set of simultaneous parameterized type equations and then, automatically solving those type equations to produce type difference transformations that automatically convert code from one design context to a different design context. For example, a set of solution transforms might redesign code from a simple image convolution expression within a specification context to a set of thread based, parallelized expressions of the convolution designed to fit the "holes" within a design framework from a reusable library. The type equations are expressed in terms a generalization of programming data types (called Context Qualified Types or CQ Types) that may have embedded variable parameters. In addition to programming data type information, CQ Types incorporate design features or concepts that fall outside of the programming data type domain (e.g., a planned program scope or a design skeleton).

16 Claims, 20 Drawing Sheets

